CLAIMS

What is claimed is:

1. A high temperature stable catalyst support comprising:

an alumina phase selected from the group consisting of alpha-alumina, theta-alumina and combinations thereof; and

a rare earth aluminate comprising at least one rare-earth metal,

wherein the rare earth aluminate has a molar ratio of aluminum to rare-earth metal greater than 5, and

wherein the catalyst support contains between about 1 wt% and about 50 wt% of rare earth aluminate.

2. The catalyst support of claim 1 wherein the catalyst support comprises between 5 and 50 percent by weight of rare earth aluminate based on the total weight of the catalyst support.

3. The catalyst support of claim 1 wherein the rare earth metal is selected from the group consisting of lanthanum, neodymium, praseodymium, cerium, samarium, and combinations thereof.

4. The catalyst support of claim 1 wherein the rare earth aluminate comprises lanthanum.

5. The catalyst support of claim 1 wherein the catalyst support comprises between about 1 wt% and about 10 wt% of lanthanum.

6. The catalyst support of claim 1 wherein the rare earth aluminate further comprises an element from Groups 1-14 of the Periodic Table of Elements.

7. The catalyst support of claim 1 wherein the rare earth aluminate further comprises nickel, magnesium, barium, potassium, sodium, manganese, a second rare earth metal and combinations thereof.

8. The catalyst support of claim 1 wherein the rare earth aluminate and the alumina phase are intimately mixed.

9. The catalyst support of claim 1 wherein the rare earth aluminate at least partially coats the alumina phase.

10. The catalyst support of claim 1 wherein the rare earth aluminate comprises a hexaaluminate structure, a beta-aluminate structure, or combinations thereof.

11. The catalyst support of claim 1 wherein the rare earth aluminate has a chemical formula of $LnAl_yO_z$, where y is between 11 and 14; and z is between 18 and 23, and where Ln comprises lanthanum, neodymium, praseodymium, samarium, cerium, or combinations thereof.

12. The catalyst support of claim 1 wherein the rare earth aluminate has a chemical formula of MAl_yO_z, where y is between 11 and 12; z is between 18 and 19; and M comprises a combination of lanthanum and samarium.

13. The catalyst support of claim 1 wherein the rare earth aluminate comprises a lanthanum hexaaluminate.

14. The catalyst support of claim 1 further comprising rare earth aluminate with an aluminum to rare earth metal ratio less than 2:1.

15. The catalyst support of claim 1 further comprising a rare earth aluminate with a perovskite structure.

16. The catalyst support of claim 1 further comprising an oxide of said rare earth metal.

17. The catalyst support of claim 1 wherein the catalyst support has a surface area greater than 2 m^2/gram.

18. The catalyst support of claim 1 wherein the catalyst support has a surface area lower than 30 m^2/gram.

19. The catalyst support of claim 1 wherein the catalyst support comprises between 1 wt% and 10 wt% of rare earth metal.

20. The catalyst support of claim 1 wherein the catalyst support is made by impregnating a solution of a rare earth metal onto an aluminum-containing precursor; and calcining at a temperature greater than 1,000 °C.

21. The catalyst support of claim 20 wherein the aluminum-containing precursor comprises an aluminum structure selected from the group consisting of bayerite, gibbsite, boehmite, pseudo-boehmite, bauxite, gamma-alumina, delta-alumina, chi-alumina, rho-alumina, kappa-alumina, eta-alumina, theta-alumina, and combinations thereof.

22. The catalyst support of claim 20 wherein the aluminum-containing precursor comprises at least one transition alumina selected from the group consisting of gamma-alumina, delta-alumina, chi-alumina, rho-alumina, kappa-alumina, eta-alumina, and theta-alumina.

23. The catalyst support of claim 20 wherein the aluminum-containing precursor comprises mostly gamma-alumina.

24. The catalyst support of claim 23 wherein calcining is done at a temperature between 1,000°C and 1,600°C.

25. The catalyst support of claim 23 wherein calcining is done at a temperature between 1,100°C and 1,400°C.

26. A method for making a thermally stable aluminum-based catalyst support comprising:

(a) impregnating a solution of a rare earth metal onto an aluminum-containing precursor;

(b) drying the impregnated aluminum-containing precursor; and

(c) calcining in a manner effective to convert a portion of said aluminum-containing precursor to an aluminum oxide phase comprising alpha-alumina, theta-alumina, or combinations thereof, and to convert another portion of said aluminum-containing precursor with at least a fraction of said rare earth metal to a rare earth aluminate with a molar ratio of aluminum to rare earth metal greater than 5, such that the catalyst support comprises between about 1 wt% and about 50 wt% of said rare earth aluminate.

27. The method of claim 26 wherein the aluminum-containing precursor comprises an aluminum structure selected from the group consisting of bayerite, gibbsite, boehmite, pseudo-boehmite, bauxite, gamma-alumina, delta-alumina, chi-alumina, rho-alumina, kappa-alumina, eta-alumina, theta-alumina, and combinations thereof.

28. The method of claim 26 wherein the aluminum-containing precursor comprises a transition alumina selected from the group consisting of gamma-alumina, delta-alumina, chi-alumina, rho-alumina, kappa-alumina, eta-alumina, theta-alumina, and combinations thereof.

29. The method of claim 26 wherein the aluminum-containing precursor comprises mostly gamma-alumina.

30. The method of claim 29 wherein calcining is done at a temperature between 1,000 °C and 1,600 °C.

31. The method of claim 29 wherein calcining is done at a temperature between 1,100 °C and 1,400 °C.

32. The method of claim 26 wherein the rare earth metal is selected from the group consisting of lanthanum, neodymium, praseodymium, cerium and combinations thereof.

33. The method of claim 26 wherein the rare earth aluminate comprises lanthanum.

34. The method of claim 26 wherein calcining is further effective to convert a portion of the rare earth metal solution into an oxide of said rare earth metal, said rare earth oxide consisting essentially of rare earth metal atoms and oxygen atoms.

35. The method of claim 26 wherein the solution of rare earth metal comprises more than one rare-earth metal.

36. The method of claim 26 wherein the rare earth aluminate comprises a hexaaluminate structure, a beta-aluminate structure, or combinations thereof.

37. The method of claim 26 wherein the rare earth aluminate comprises a lanthanum hexaaluminate.

38. The method of claim 26 wherein the catalyst support comprises between about 0.5 and about 10 percent by weight of rare earth metal based on the total weight of the catalyst support.

39. The method of claim 26 wherein the catalyst support comprises between about 5 and about 50 percent by weight of rare earth aluminate based on the total weight of the catalyst support.

40. A partial oxidation catalyst comprising:

(a) an active ingredient selected from the group consisting of rhodium, iridium, platinum, palladium, and ruthenium; and

(b) a support comprising

an alumina phase selected from the group consisting of alpha-alumina, theta-alumina and combinations thereof; and

a rare earth aluminate comprising a rare-earth metal, wherein the rare earth aluminate has a molar ratio of aluminum to rare-earth metal greater than 5, and wherein the support comprises between about 1 and about 50 percent of said rare earth aluminate by weight of the total weight of the support.

41. The partial oxidation catalyst of claim 40 wherein the rare earth aluminate comprises an hexaaluminate structure, a beta-aluminate structure, or combinations thereof.

42. The partial oxidation catalyst of claim 40 wherein the rare earth aluminate comprises a lanthanide hexaaluminate.

43. The partial oxidation catalyst of claim 42 wherein the lanthanide hexaaluminate comprises a lanthanide metal selected from the group consisting of lanthanum, neodymium, praseodymium, and combinations thereof.

44. The partial oxidation catalyst of claim 42 wherein the lanthanide hexaaluminate comprises lanthanum.

45. The partial oxidation catalyst of claim 40 wherein the rare earth metal is selected from the group consisting of lanthanum, neodymium, praseodymium, and combinations thereof.

46. The partial oxidation catalyst of claim 40 wherein the rare earth aluminate comprises lanthanum.

47. The partial oxidation catalyst of claim 40 wherein the rare earth aluminate comprises more than one rare-earth metal.

48. The partial oxidation catalyst of claim 40 wherein the support has a surface area greater than 2 m^2/gram.

49. The partial oxidation catalyst of claim 40 wherein the support comprises between about 5 and about 50 percent by weight of the rare earth aluminate based on the total weight of the support.

50. A method for making synthesis gas comprising:

converting a gaseous hydrocarbon stream and an oxygen-containing stream over a partial oxidation catalyst, to make a product stream comprising CO and H_2,

wherein said partial oxidation catalyst includes

an active ingredient comprising a metal selected from the group consisting of rhodium, iridium, platinum, palladium, ruthenium, and combinations thereof; and

a support comprising a rare earth aluminate, said rare earth aluminate having a molar ratio of aluminum to rare-earth metal greater than 5:1.

51. The method of claim 50 wherein the support comprises between about 1 and about 50 percent of said rare earth aluminate by weight based on the total weight of the support.

52. The method of claim 50 wherein the rare earth metal is selected from the group consisting of lanthanum, neodymium, praseodymium, cerium, and combinations thereof.

53. The method of claim 50 wherein the rare earth aluminate comprises lanthanum.

54. The method of claim 50 wherein the support comprises between about 1 and about 10 percent by weight of lanthanum based on the total weight of catalyst support.

55. The method of claim 50 wherein the rare earth aluminate comprises lanthanum and samarium.

56. The method of claim 50 wherein the support further comprises an alumina phase selected from the group consisting of alpha-alumina, theta-alumina and combinations thereof.

57. The method of claim 56 wherein the rare earth aluminate and the alumina phase are intimately mixed.

58. The method of claim 56 wherein the rare earth aluminate at least partially coats the alumina phase.

59. The method of claim 50 wherein the rare earth aluminate comprises a hexaaluminate structure, a beta-aluminate structure, or combinations thereof.

60. The method of claim 50 wherein the rare earth aluminate comprises a lanthanum hexaaluminate.

61. The method of claim 50 wherein the support comprises between about 1 wt% and about 10 wt% of rare earth metal.

62. The method of claim 50 wherein the conversion is done at a GHSV between about 20,000 hr^{-1} to about 100,000,000 hr^{-1}.

63. The method of claim 50 wherein the conversion is done at a temperature between about 350 °C to about 2,000 °C.

64. The method of claim 50 wherein the conversion is done at a pressure between about 100 kPa to about 4,000 kPa.

65. The method of claim 50 wherein the hydrocarbon stream comprises natural gas.

66. The method of claim 50 wherein the hydrocarbon stream comprises mainly methane.

67. The method of claim 50 wherein the partial oxidation catalyst comprises rhodium.

68. The method of claim 67 wherein the partial oxidation catalyst comprises between about 0.5 wt% and about 10 wt% of rhodium.

69. The method of claim 67 wherein the partial oxidation catalyst has a rhodium surface area greater than about 0.5 m^2/g.

70. The method of claim 67 wherein the partial oxidation catalyst further comprises samarium.

71. The method of claim 50 wherein the catalyst exhibits hydrocarbon conversion of equal to or greater than about 85%.

72. The method of claim 50 wherein the partial oxidation catalyst has a hydrogen selectivity equal to or greater than about 85%.

73. The method of claim 50 wherein the product stream comprising CO and H_2 has a H_2:CO molar ratio between about 1:4:1 and 2.3.

74. The method of claim 50 wherein at least a portion of the product stream comprising CO and H_2 is further converted to hydrocarbons.

75. A method for making synthesis gas comprising:

converting a gaseous hydrocarbon stream and an oxygen-containing stream over a partial oxidation catalyst, to make a product stream comprising CO and H_2,

wherein said partial oxidation catalyst includes

an active ingredient comprising rhodium, iridium, platinum, palladium, ruthenium, or combinations thereof; and

a support comprising theta-alumina.